ECOLOGY AND LIFE HISTORY OF THE
CLOWN GOBY, MICROGOBIUS GULOSUS
INHABITING THE UPPER BANANA RIVER,
CAPE CANAVERAL, FLORIDA
(Pisces: Gobiidae)

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ABSTRACT

Monthly collections of Clown goby *Microgobius gulosus* were made from March 1984 through February 1985 at two stations located at the head of the Banana River, Brevard County, Florida as part of the long term environmental monitoring program at the John F. Kennedy Space Center. A total of 18,921 fishes comprising eight families and 12 genera was collected. *M. gulosus* represented 6.4% of the total catch. Populations of *M. gulosus* exhibited aggregation behavior which varied in intensity depending on densities and habitat characteristics. Capture data were best decribed by the negative binomial distribution. Mean estimates of individuals per m^2 ranged from 0.0 to a high of 22.1 during periods of peak recruitment. The total length-weight regression for all individuals measured was Log W=-4.65 + 2.72 Log L. *M. gulosus* obtained a size of 35-40 mm TL the first year and 50-60 mm TL the second year. Total lengths of all specimens ranged from 11 to 71 mm. Young of the year first appeared in May with smallest individuals collected in June and July. A protracted spawning period was observed. Stomach and gut analyses revealed crustaceans and annelids combined represented 65% and 66% of the total diet for *M. gulosus* from stations 1 and 2, respectively. Differences in proportions of the two groups were present between the two stations. Crustaceans represented 47.1% of the diet for gobies collected at station 1 and annelids 40.8% for specimens collected from station 2. Fecundity was low with the mean number of ova being 305 $\pm$ 77.5 for females between 35 and 49 mm TL. Estimated mortality rate was approximately 95% annually.

INTRODUCTION

The genus *Microgobius* Poey includes 14 species of American seven-spined gobies. Of these, six are western Atlantic and eight are eastern Pacific inhabitants (Bohlke and Robins 1968). Four western Atlantic species, *M. carri*, *M. microlepis*, *M. gulosus* and *M. thalassinus*, are reported from the Indian River Lagoon System and adjacent waters of southeast Florida (Gilmore et al. 1981, 1983). Snelson (1980, 1983) and Schooley (1980) reported that only *M. gulosus* and *M. thalassinus* have been collected in the northern portion of the Indian River Lagoon System, with the former being most common.

Several investigators have reported on the range, general ecology and biology of *M. gulosus*. Ginsburg (1934) addressed the distinction between *M. gulosus* and *M. thalassinus* with detailed descriptions of the two species and a discussion of qualitative habitat associations and locations of capture along the Gulf of Mexico coast. Kilby (1955) collected 256 specimens of *M. gulosus*, noting such information as size range, time of spawning and habitat characteristics, including substrate type, vegetation coverage and salinity associations in a study designed to define fish species abundance and distribution in brackish water marshes near Bayport and Cedar Key, Florida. Reid (1954) investigated fishes of shallow brackish waters and channels at Cedar Key, Florida. His reference to *M. gulosus* highlighted information on its biology including habitat association, spawning, diet and coloration patterns relating to habitat characteristics. Springer and Woodburn (1960) made brief reference to habitat association, spawning and diet of _M. gulosus_ in an ecological study of fishes of Tampa Bay, Florida. Baird (1965) collected specimens from Nine Mile Pond near Rockport, Texas and noted on the ecology, behavior and diet. He assessed the value of strong sexual dimorphism and its influence on niche expansion and differential niche utilization. His descriptive account of the general habitat from which specimens were collected qualitatively defined habitat associations for populations occurring along the Gulf coast states.

Dawson (1969), in a key to common gobioid fishes inhabiting estuaries of the northern Gulf of Mexico, described _M. gulosus_ and made general statements as to habitat association and distribution. A comprehensive study that reviewed the systematics of the genus _Microgobius_ and redescribed the species was presented by Birdsong (1981). He reported on several species, including _M. gulosus_, including information on ecology, habitat association, salinity tolerance, nesting behavior, spawning, diet and distribution.

M. gulosus is rarely collected north of the St. Johns River, Jacksonville, Florida (Lee et al. 1980, Sandifer et al. 1980, Birdsong 1981). Schwartz (1971) documented a single collection of 32 specimens in the vicinity of the Patuxent River, Maryland on 5 February 1962 as its northern range. The southernmost population occurs in the Florida Keys (Birdsong 1981). _M. gulosus_ also occurs along the Gulf coast to the Mississippi delta. Gosselink et al. (1979) and Lee et al. (1980) reported _M. gulosus_ absent from the Chenier Plain region of west

Louisiana and east Texas, yet populations are present in the region of Corpus Christi, Texas.

The shallow water fish fauna at the head of the Banana River, Brevard County, Florida and its associated impounded marshes was investigated between March 1984 and February 1985 as part of the long-term environmental monitoring program at the John F. Kennedy Space Center (Hall et al. 1985). Discussions included in this paper pertain to catch distribution, density, biomass, relative abundance, food habits, habitat associations, length-weight relationships, population statistics and reproductive characteristics of M. gulosus on the east coast of central Florida.

MATERIALS AND METHODS

Monthly collections were made using a 1 m^2 toss net modified after Kushlan (1981). The frame, made of T6 aluminum pipe, stood 75 cm high and was fitted with a 3.1 mm stretch mesh, tar coated, nylon netting. A canvas hem, designed to retard wear of the net material, was sewn onto the netting where it wrapped around both the upper and lower piping. A panel with increments of 5 cm markings was also sewn onto the sides of the netting to facilitate depth measurements of each sample. Following a toss, when one side of the frame was substantially lower than the opposite side, an average of the two depths was recorded. Samples were rejected if the frame failed to land or seat properly on a substrate. A dip net made of the same material as the frame with dimensions slightly less than 1 m^2 was used to collect fishes from inside the toss net. Vegetation type and percent coverage, inside the net, were determined via visual and tactile inspection. Sampling inside the toss net continued until all fishes were removed or until three consecutive scoops, plus a visual and a tactile inspection of the enclosure, failed to reveal the presence of specimens. Specimens were preserved in 10% formalin and later transferred to 45% isopropyl alcohol.

Fishes were measured in the laboratory, using a Scherr Tumico stainless steel caliper and wet weighed (0.001 g) using an electronic toploading Mettler PE160 balance. All sex determinations were made via dissections. Gonadal material was removed by dissection and wet weighed on an analytical Mettler H5 balance (0.0001 g). Ovaries of selected specimens were dissected and the ripening ova counted following Bagenal (1967). No effort was made to count ova from specimens with ovaries too small and fragile to dissect. Ripening ova were identified as those with a yellowish color in small specimens and a darker gold color in larger specimens. Egg diameters were measured using an Olympus BH2 microscope (100x) with a calibrated ocular micrometer.

Water quality parameters, including temperature, conductivity, salinity and station depth, were measured at a permanent station marker positioned at the southern end of each of the two sites using either a Yellow Springs Instruments (YSI) model 51b and a YSI model 33 or a Hydrolab model 8000 field surveyor. Statistical and graphical data analyses were conducted with SPSS/PC+ (Norusis 1986), ELEFAN (Brey and Pauly 1986) on an IBM PC/AT, and STAT80 (Fullerton 1983) and Grafit (Graphicus

1986) on a Hewlet Packard 1000. The data analysis strategy followed a structured approach that involved data summarization, calculation of basic statistics, transforming data where necessary, calculation of bivariate measures of association and hypothesis testing (Comiskey and Brandt 1982). A significance level of 0.05 was used during all statistical tests to denote significance. A gonadosomatic index (GSI) was calculated by dividing the gonad weight by the somatic weight (somatic weight = total weight minus gonad weight) (Bagenal 1967) and multiplying the result by 100. An importance value (IV) was calculated for each month at each station according to Mulligan and Snelson (1983). Length-weight regressions and analysis of covariance were conducted to evaluate possible differences in the relative condition of *M. gulosus* that might occur as a result of sexual dimorphism or differences in habitat quality (Lagler 1956). Population statistics including recruitment pattern and mortality rates were calculated according to Ricker (1975) and Brey and Pauley (1986).

STUDY AREA

Two separate bodies of water located at the head of the Banana River (Figure 1) were sampled. Station 1 was a small lagoon (3.6 ha) with access to the Banana River via a canal approximately 30 m wide and 2 m deep. The average depth of the lagoon was 75 cm with a maximum of 2 m near the center. Dominant submerged aquatic vegetation (SAV) was widgeon grass (*Ruppia maritima*) and to a lesser extent shoal grass (*Halodule *wrightii*). Substrate at station 1 was comprised of 0.5% shell, 97% sand and 2.5% silt and clay. Station 2 was located directly north of station 1 and was nearly equal in size. The two sites were separated by an earthen dike. The average depth at station 2 was about 1 m. Dominant SAV species were *R. maritima* and *Chara* spp. The substrate was similar to station 1, however the presence of large numbers of the bivalve *Geukensia demissa* along the shoreline and among the saltmarsh cordgrass (*Spartina alterniflora*), altered the substrate ratios to 2% shell, 97% sand and 1% silt and clay. Water temperature, salinity and depth measurements are presented in Figure 2.

RESULTS AND DISCUSSION

Abundance and Biomass

A total of 18,921 fishes representing 13 species were collected in 230 samples from the two stations. *M. gulosus* comprised 6.4% of the total catch or 1217 specimens. At station 1, 263 *M. gulosus* were collected in 43.3% or 52 of 120 samples, while at station 2, 954 individuals were collected in 79.1% or 87 of 110 samples. Analysis of the distribution of catch data indicated a statistically significant fit to the negative binomial distribution for samples from both sites, a common sample distribution for biological specimens displaying behavioral aggregations (Taylor 1953, Cox 1980). *M. gulosus* was not uniformly or randomly distributed throughout the study area. Statistical tests for fits to these distributions were not significant. Cox (1980) states that the value of K, the exponent from the negative binomial distribution, is representative of the degree of intraspecific aggregation with lower values representing a more highly clumped condition. Station 1 had a K value of 0.2497 while station 2 had a K value of 0.5575. These results strongly suggested differences in aggregation characteristics between the two sample areas. Factors influencing observed aggregation may include sample area, trophic structure, habitat charateristics and species abundance.

A t-test was conducted to compare mean number of individuals per m^2 between stations. Overall mean at station 1 (2.19) was significantly lower than the mean at station 2 (8.67) for areas in which samples could be collected (Table 1). This difference in density may in part be responsible for observed differences in catch distributions between the two sites.

No estimates of densities for *M. gulosus* have been reported in the literature, but information regarding density estimates of other gobioid fishes from similar habitats was available. Crabtree and Dean (1982) estimated densities of 7.7 *Gobiosoma bosci* per m^2 in the North Edisto and 25.2 fish per m^2 in the Leadenwah pools, South Carolina. Nero (1976) estimated densities of *G. bosci* in Chesapeake Bay to be 8.0 fish per m^2. Hoese (1962) estimated *G. bosci* densities of 4.9 fish per m^2 in the bayside eastern shore of Virginia.

Monthly mean densities of *M. gulosus* at station 1 ranged from 0.0 in April to 7.1 individuals per m^2 in October. Mean densities at station 2 declined from 22.1 in May to 0.9 fish per m^2 in August. High densities at station 2 in May and June corresponded to strong recruitment of young of the year individuals, a pattern not observed at station 1. Mean biomass, in general, followed trends in mean abundance at both stations. The greatest deviation between mean biomass and mean abundance occurred at station 2 with the influx of young of the year between April and May adding substantially to mean abundance while contributing little to mean biomass. Mean abundance and biomass at station 1 equaled or exceeded station 2 only in August and September.

Community and Trophic Characteristics

Year round resident taxa, by order of dominance, at station 1 included *Poecilia latipinna*, *Lucania parva*, *Gambusia affinis*, *Gobiosoma* spp. and *M. gulosus*. The order of resident dominance at station 2 was *G. affinis*, *Gobiosoma* spp., *P. latipinna*, *M. gulosus* and *L. parva* (Table 2). Differences in community and trophic structure existing between impounded and open water areas was similar to those noted by Schooley (1980). The catch at station 1 included three taxa (*Anchoa mitchilli*, *Microgobius thalassinus* and *Syngnathus scovelli*) not observed at station 2. *Mugil cephalus* was the only commercially important species collected.

Calculations of Pearson product-moment correlations revealed unspectacular but significant negative relationships between *M. gulosus* and *P. latipinna* (r=-0.13) and *L. parva* (r=-0.19). A significant positive correlation (r=0.53) existed for *M. gulosis* and *Gobiosoma* spp. The slight negative correlation between *M.*

gulosus and P. latipinna and L. parva may be indicative of differences in habitat preference. P. latipinna and L. parva were positively correlated with each other (r=0.49) and were usually found associated with SAV. These two taxa had positive correlations with R. maritima of r=0.20 and r=0.29, respectively. M. gulosus was negatively correlated (r=-0.13) with percent coverage of R. martima.

Previous investigators have indicated a variety of habitat associations for M. gulosus. Reid (1954) collected specimens from shallow sand flats and also found individuals in deeper flats and channels. During summer, these shallow flats were vegetated with H. wrightii, S. filiforme, turtle grass (Thalassia testudinum) and R. maritima. At Nine Mile Pond, Baird (1965) found specimens associated with mud and little vegetation while Ginsburg (1934) collected specimens from ponds, bayous or in small coves on a muddy or occasionally grassy substrate. Springer and Woodburn (1960), Clark (1971) and Birdsong (1981) suggested that M. gulosus appears to prefer protected areas with muddy substrates and vegetation. Odum (1971) and Gilmore et al. (1981) collected individuals from shallow water along river banks and small creeks. M. gulosus was common in grassflats, open sand, lagoon reefs and occasionally among mangroves (Gilmore et al. 1981). Prior to evaporative dewatering, resulting in hypersaline conditions (60-150 ppt), M. gulosus was found in impounded waters (Gilmore et al. 1982). Kilby (1955) collected 95% of his specimens from outer pools at Cedar Key. Pools were defined as small shallow bodies of water which typically lacked emergent vegetation, were surrounded by *S. alterniflora* and retained water during low tides. Mean salinities ranged from 15.4 to 30.2 ppt. He also observed that it was most abundant in the deepest part of the outer pools. Birdsong (1981) showed at Big Pine Key, Florida the distribution of *M. gulosus* in a 3 m deep channel to be in areas of little current with fine sediments. Subrahmanyam and Coultas (1980) noted preference for upper marshes where isolated ponds exist. These marshes had little daily disturbance and a mean of 81% of the sediments (from two separate high marshes) were composed of sand. Tagatz (1968) collected *M. gulosus* from the St. Johns River where substrates were muck to mud/sand. Livingston (1976) collected several individuals in Apalachicola Bay where mud substrates prevailed (Laughlin 1982).

IV estimates were lowest at station 1 in April and June. In August, *M. gulosus* ranked 5th of eight species captured, gradually increased in monthly IV until December, when it was 1st of seven species collected. Monthly IV estimates at station 2 were similar to those observed for station 1. Low values occurred in April and August. Peak IV estimates closely coincided with those observed for station 1.

M. gulosus at station 1, ranked 7th (IV=23.3) out of 13 species collected during the entire year; at station 2, *M. gulosus* ranked 5th (IV=24.9) out of 10 species (Table 2). However, in each case *M. gulosus* represented 5.6% and 6.7% of the total catch at each station, respectively. This was similar to Whitewater Bay, Florida, where *M. gulosus* was identified as the

3rd most abundant species collected, representing just over 6% of the total catch (Clark 1971). Subrahmanyam and Coultas (1980) showed _M. gulosus_ in a north Florida saltmarsh as 21st out of 47 species collected with occurrences in 12% of their samples. In the high marsh where less disturbance occurred, _M. gulosus_ was present 67% of the time and ranked 8th out of 19 species encountered.

Differences in community structure observed at our two sites may be attributed in part to differences in habitats and the resulting trophic structures and interactions. This hypothesis was evaluated through food habit analysis for _M. gulosus_. A total of 234 specimens was examined from station 1; the stomach and gut contents of 159, or 67.9% were found to contain food. The principal identifiable component of the clown goby's diet was Crustacea comprising 47.1% of the total (Figure 5). The tanaid _Hagaria rapax_ represented 68.0%, unidentifiable amphipoda 20.0%, decapoda (_Palaemonetes_ spp.) 6.7% and cumacea and other unidentifiable crustacea 5.3%. Annelida contributed 18.9% and fish, 6.3% to the goby's diet of the contents. UNIDOM (unidentifiable organic matter) represented 25.2%.

The stomach and gut contents of 317 or 87.3% of 363 specimens from station 2 possessed food items. The principal identifiable component was annelida (40.8%). Crustacea represented 24.5%. These crustaceans consisted of 37.2% decapoda (_Palaemonetes_ spp.), 32.1% ostracoda, 25.6% copepoda, 3.8% other unidentifiable crustacea and 1.3% cumacea. UNIDOM represented

29.0% and fishes 3.5% of the total foods eaten. The principal foods were crustaceans and annelids. Reid (1954), upon examining the stomachs of specimens 45-57 mm SL, found copepods, mysids and amphipods (in order as written) were the main foods in the clown goby's diet at Cedar Key. Specimens collected from Nine Mile Pond, Texas appeared to feed primarily on larval shrimp and amphipods while in laboratory studies, M. gulosus fed on, in addition to those items mentioned above, larval fish including its own larvae (Baird 1965). Springer and Woodburn (1960) identified polycheates, small bivalves and algae as part of the diet. Odum (1971) analyzed the stomach contents of 18 M. gulosus, from North River Estuary of the Everglades National Park, Florida and found 43% amphipods, 21% harpacticord copecods in the diet. Cladocerans, algal strands, mysids, cumaceans and chironomid larvae were also identified as dietary components.

Population Characteristics

Assessment of length-weight relationships permitted examination of possible difference in relative condition between individuals from the two sites, juveniles and adults and males and females. Differences may be related to age, sex, trophic structure or habitat quality (Lagler 1956). No information on this subject has been reported in the literature for M. gulosus. All length-weight regressions of the log 10 transformed data were highly significant (Table 3). The total length total weight regression for all individuals measured is presented as equation one (Table 3). Equations two and three represented juveniles (11-30 mm TL) and adults (>30 mm TL), respectively (Schooley 1980).

Differences in the slopes and intercepts for equations two and three indicated that the growth pattern for M. gulosus was allometric. Adults gained more weight per unit increase in length than young. This may be related to sexual maturation and the resultant gonad development. Analysis of covariance (Kleinbaum and Kupper 1978) was conducted to examine possible differences in length-weight relationships between sample sites and sexes. The length-weight regressions for adult males and females were not significantly different in slope ($z=1.156$) or intercept ($z=-1.203$). Similarly, no significant differences were observed between slopes ($z=.9478$) or intercepts ($z=1.079$) for the two stations, based on a common subset of adult individuals between 30 and 60 mm TL. The pooled regression (equation three) for all individuals greater than 30 mm TL was therefore considered representative of adults for both stations and sexes.

Equation 4 represents the relationship between standard length and total length for M. gulosus based on measurements of 506 individuals. It was highly significant ($r^2=0.99$), making it possible to convert length data from one measurement to another with a high degree of accuracy.

Total lengths for specimens from stations 1 and 2 ranged between 11 and 71 mm (Figure 6a-c). Young of the year individuals first appeared in May 1984, with smallest individuals (11 mm TL) being collected in June and July. Along the west coast of Florida, Kilby (1955) collected the smallest fish at

Bayport in late September, while at Cedar Key the smallest specimens were collected in May (12 mm SL). Plankton samples at Nine Mile Pond revealed the presence of M. gulosus larvae 10 mm SL in June and July (Baird 1965). Tagatz (1968) collected specimens less than 20 mm FL during May, August and October through December in a two and a half year study of the fishes of the St. Johns River. Grouping months for three years (April 1961-November 1963), the total abundance of M. gulosus during October through December was substantially higher than any previous months, while lengths of fish obtained were smallest during this period (Tagatz 1968).

Estimation of the annual recruitment pattern based on fish length frequency data (Brey and Pauly 1986), indicated less than 10% of the total recruitment occurred between the months of December and April. Recruitment increased sharply in May to approximately 10%, fluctuated between 14 and 19% from June through September, then declined gradually in October and November. This recruitment pattern along with the occurrence of individuals less than 20 mm TL during the months of May through October and in the collection of December 27, defined a protracted spawning period for M. gulosus, in the waters of the east coast of central Florida. Kilby (1955) believed, as did Reid (1954) that M. gulosus possessed an extended breeding season. Reid's collection of M. gulosus measuring 15-20 mm SL in May, June and October illustrated a protracted breeding season for populations occurring along the west coast of central Florida. Birdsong (1981) speculated that populations occurring in southern Florida may experience spawning throughout the year. Samples obtained from Bayport and Cedar Key (Kilby 1955), in which M. gulosus <25 mm SL were collected during each season also indicated protracted spawning. Ripe individuals were observed in Tampa Bay in July and November (Springer and Woodburn 1960).

Results of catch curve analyses (Brey and Pauly 1986) to define growth rates and other population statistics by ELEFAN indicated:

1. Individuals may obtain lengths of 35 to 40 mm TL during their first year. Age II individuals typically grow an additional 15 to 20 mm TL. Growth in individuals beyond Age II was less than 10 mm TL per year.
2. The calculated Brody growth coefficient (K) was 0.62 and the mean asymptotic length was 74.9 mm.
3. The instantaneous mortality rate for the population sampled was 2.94 which produced an annual expectation of death (A) or annual mortality rate of approximately 95% (Ricker 1975).

Thus, few individuals live beyond age II and growth of those that do is slow. Only three individuals greater than 70 mm TL were captured during our study. One possible source of bias that should be considered when interpreting these results is maximum water depth from which our samples were collected. Larger and older individuals may inhabit deeper waters resulting in underestimates of maximum size obtained and overestimates of mortality rates.

Ovaries from specimens from station 2 were examined microscopically to analyze fecundity rates. The mean number of ova in 25 individuals, ranging between 35 and 49 mm TL, was 305.52 $\pm$ 77.45. Total mean egg diameter in four of these 25 individuals (41-49 mm TL), was 0.66 $\pm$ 0.21 mm with a mean ova range of 0.43 to 0.89 mm. Eggs in these four specimens were a dark golden color and well developed. These fish possessed a distended abdomen and upon disection, both ovaries were located ventral to the intestine.

A second set of 14 adult size females (32 to 46 mm TL) lacking distended abdomens and with eggs off white to light yellow in color were also evaluated. Ovaries were dorsally positioned in relation to the intestine in these specimens. Eggs were too fragile and mucoid to be teased apart for accurate counting, however, mean diameters ranged from 0.08 to 0.61 mm.

Overall, the largest egg encountered was 1.14 mm in diameter from a 42 mm TL individual. The smallest egg measured with confidence was 0.03 mm in diameter and occurred in a 33 mm TL specimen. No significant difference was found between the numbers of eggs occurring in the left or right ovaries. The largest number of ova counted for any one fish was 567, 274 eggs in one ovary and 293 in the other.

GSI values were highest in March and April, prior to the onset of spawning, as evidenced by recruitment of young of the year in May and June (Figure 10). GSI values declined dramatically through June, then increased to a constant level in July, August and September, as indicated by ovaries in all stages of development. GSI values declined in fall and winter when few ripe individuals were observed. Recruitment of young of the year also declined during this period. GSI values for male gobies displayed no substantial deviations throughout the year.

Summary and Conclusion

This investigation provided many insights into the ecology and life history of the clown goby on the east coast of central Florida. M. gulosus populations exhibited behavioral aggregation that varied in intensity, depending on abundance and habitat characteristics. Capture data fit a negative binomial distribution. Mean densities of M. gulosus achieved levels as high as 22.1 individuals per m^2 depending on habitat and seasonal population fluctuations (recruitment). IV estimates placed M. gulosus at a mid level of the community structure based on abundance and biomass. Biomass ranged between 0 and 5 gm per m^2. Food habit analyses for gobies of the two isolated locations indicated an opportunistic feeding strategy. Crustaceans were the dominant food source at station 1 while polycheates were the principle food item at station 2. Spawning and recruitment was protracted, extending from spring through early winter (April-May to November-December). Peak recruitment occurred July through September with more occurring at station 2 than at station 1. Annual estimated growth rates were 35 to 40 mm TL for age I, 15 to 20 mm TL for age II, and less than 10 mm TL for age III or older individuals. Instantaneous mortality rate was 2.94 and the annual mortality rate was approximately 95%. Few individuals live beyond their second year. No significant differences were noted in the relative condition of the male or female fish or in specimens collected from the two isolated locations based on length-weight regressions. Growth patterns were allometric, adult fish, (>30 mm TL) gained more weight per unit length increase than did young. Individual fecundity estimates averaged 305.5 with a standard deviation of 77.5. Mean egg diameter was 0.66 mm.

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Table 1. Observed catch of *Microgobius gulosus* and calculated K and P values for fits to the negative binomial distribution.

STATION 1		STATION 2	
Number captured	263.00	Number captured	954.00
Mean	2.19/m^2	Mean	8.67/m^2
Standard deviation	4.26	Standard deviation	10.27
Minimum	0.00	Minimum	0.00
Maximum	30.00	Maximum	45.00
K	0.2497	K	0.5575
P	0.1027	P	0.060

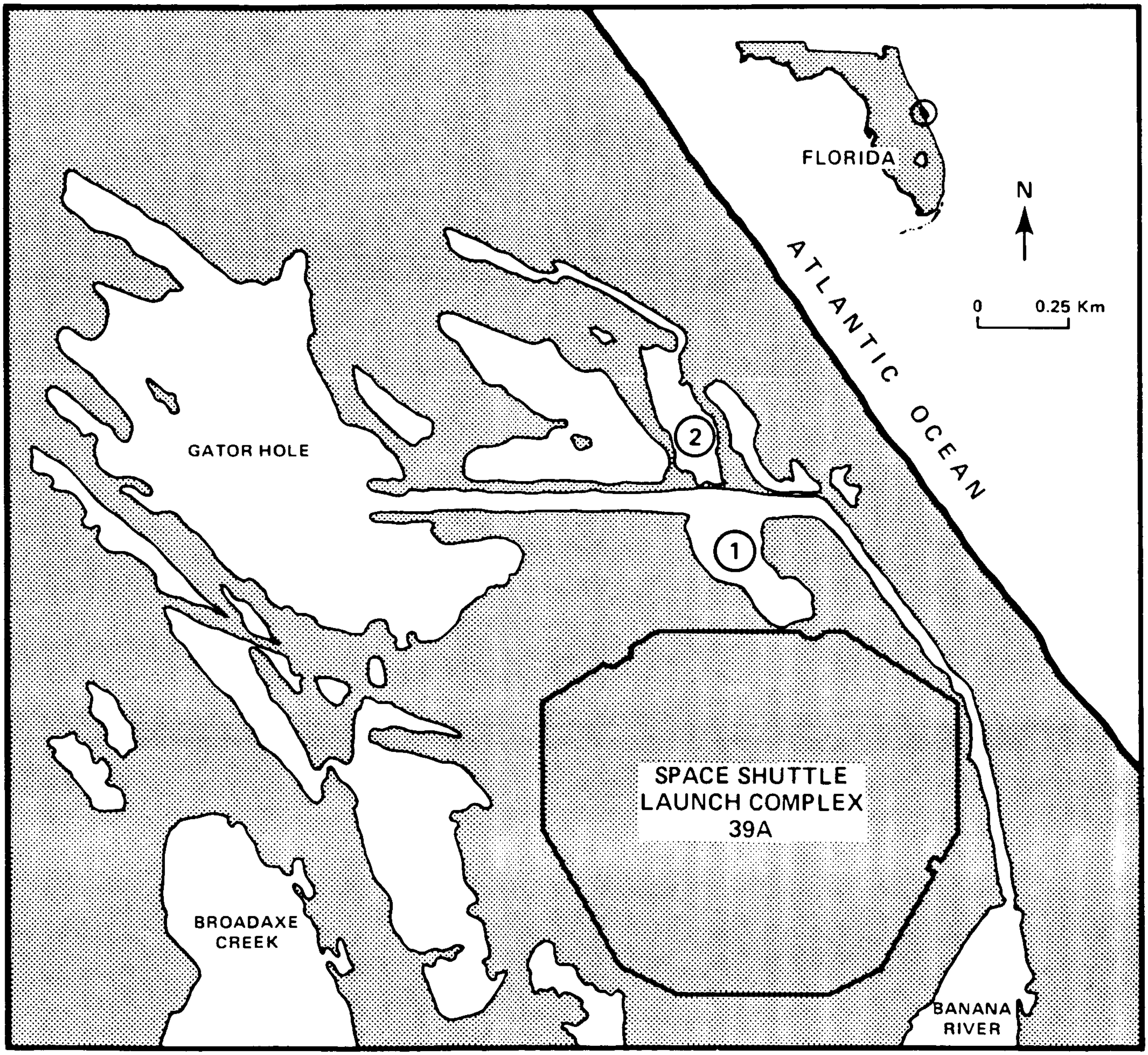
Table 2. Species ranking by importance value (IV) for stations 1 and 2 from March 1984 to February 1985. For each species, frequency of occurrence in percent, mean number caught per toss and mean biomass (g) per individual caught per toss are also given.

Species	Rank	IV	Frequency	Abundance	Biomass
Station 1					
Poecilia latipinna	1	51.2	14.0	13.100	0.002
Lucania parva	2	43.3	16.3	9.058	0.002
Elops saurus	3	42.6	0.5	0.033	0.021
Gobiosoma spp.	4	28.2	14.2	4.742	0.001
Gambusia affinis	5	27.7	9.9	6.233	0.001
Mugil cephalus	6	24.1	5.7	0.942	0.008
Microgobius gulosus	7	23.3	13.7	2.191	0.002
Syngnathus scovelli	8	16.5	11.4	1.333	0.001
Cyprinodon variegatus	9	15.3	5.7	0.642	0.004
Menidia peninsulae	10	13.6	6.7	1.150	0.002
Anchoa mitchilli	11	9.6	1.3	0.117	0.004
Fundulus grandis	12	2.2	0.2	0.008	0.001
Microgobius thalassinus	12	2.2	0.2	0.008	0.001
Station 2					
Gambusia affinis	1	67.5	18.0	62.455	0.001
Elops saurus	2	53.8	0.2	0.009	0.059
Gobiosoma spp.	3	38.6	20.0	21.618	0.002
Poecilia latipinna	4	30.7	11.9	19.482	0.004
Microgobius gulosus	5	24.9	15.8	8.673	0.003
Mugil cephalus	6	23.6	2.4	0.345	0.023
Lucania parva	7	20.3	13.3	6.727	0.002
Menidia peninsulae	8	17.3	9.7	6.273	0.003
Cyprinodon variegatus	9	13.4	8.1	3.345	0.003
Fundulus grandis	10	2.2	0.4	0.018	0.010

Table 3. Results of total weight-total length and standard length-total length regression analyses for *Microgobius gulosus*.

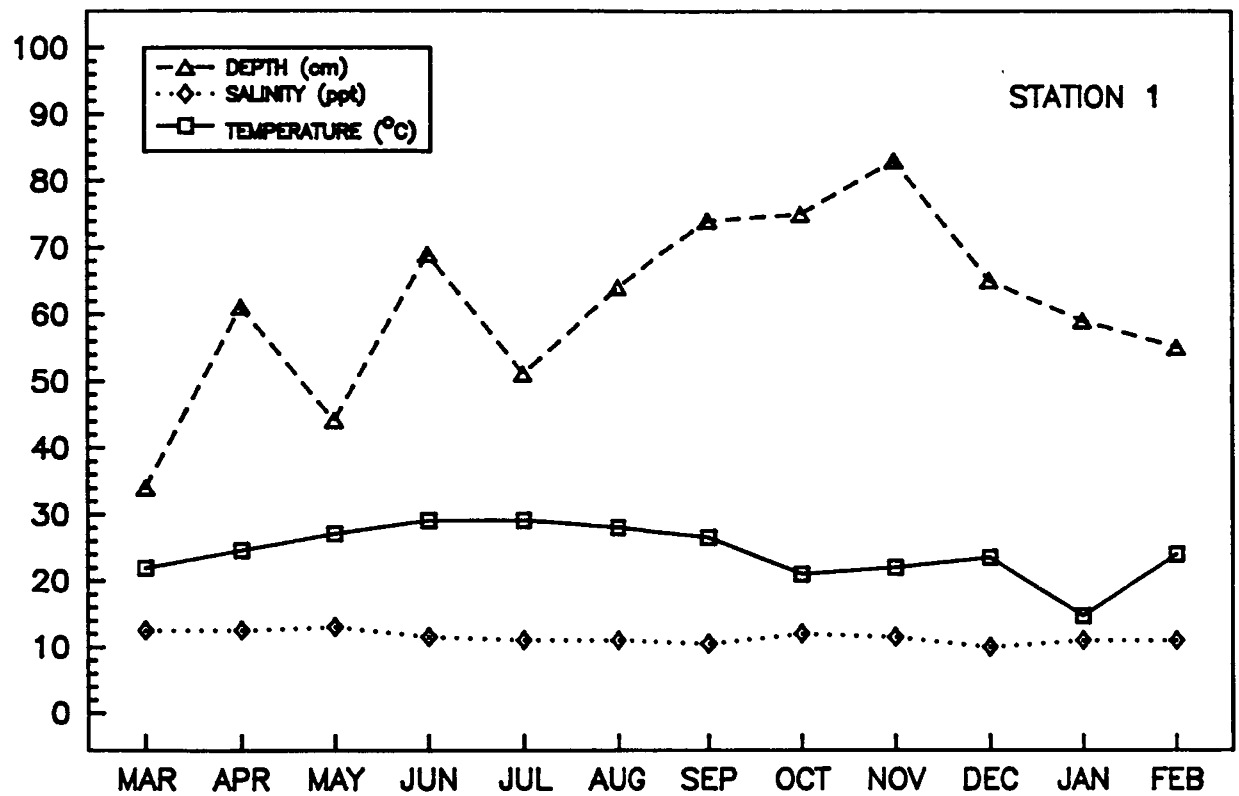
Equation	N	R^2	Length (TL)
1) $\text{Log } W = -4.65 + 2.72 \text{ Log } L$	1136	0.98	11-71 mm
2) $\text{Log } W = -.447 + 2.58 \text{ Log } L$	669	0.93	11-30 mm
3) $\text{Log } W = -5.21 + 3.06 \text{ Log } L$	467	0.97	31-71 mm
4) $SL = .155 + .782 \; TL$	506	0.99	11-71 mm

Figure 1. Study sites 1 and 2 at the head of the Banana River, Brevard County, Florida.

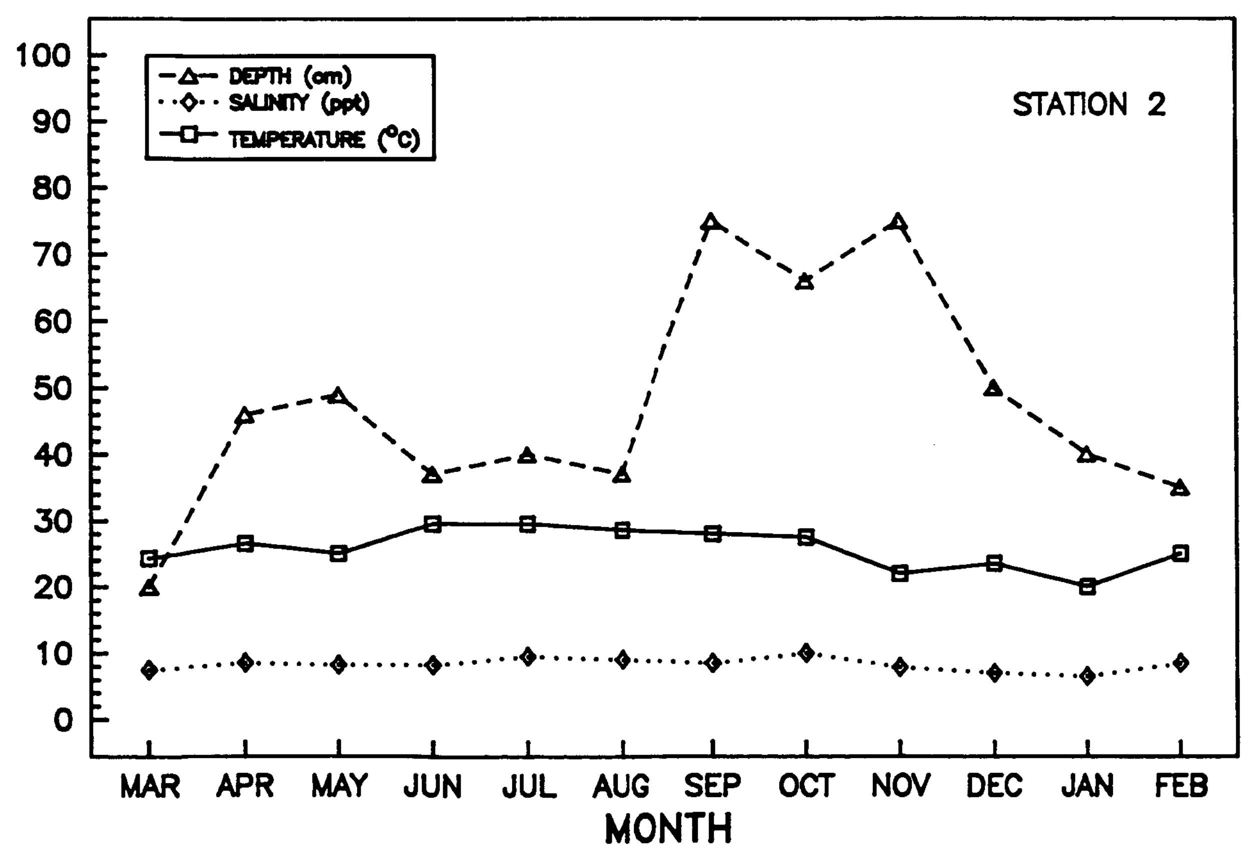


FLORIDA
N
ATLANTIC OCEAN
0 0.25 Km
GATOR HOLE
2
1
SPACE SHUTTLE
LAUNCH COMPLEX
39A
BROADAXE
CREEK
BANANA
RIVER

Figure 2. Monthly physicochemical parameters for stations 1 and 2 from March 1984 to February 1985.



DEPTH (cm)
SALINITY (ppt)
TEMPERATURE (°C)
STATION 1
100
90
80
70
60
50
40
30
20
10
0
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB



DEPTH (cm)
SALINITY (ppt)
TEMPERATURE (°C)
STATION 2
100
90
80
70
60
50
40
30
20
10
0
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MONTH

Figure 3. Monthly mean number fish per m^2 and mean biomass per m^2 for stations 1 and 2.

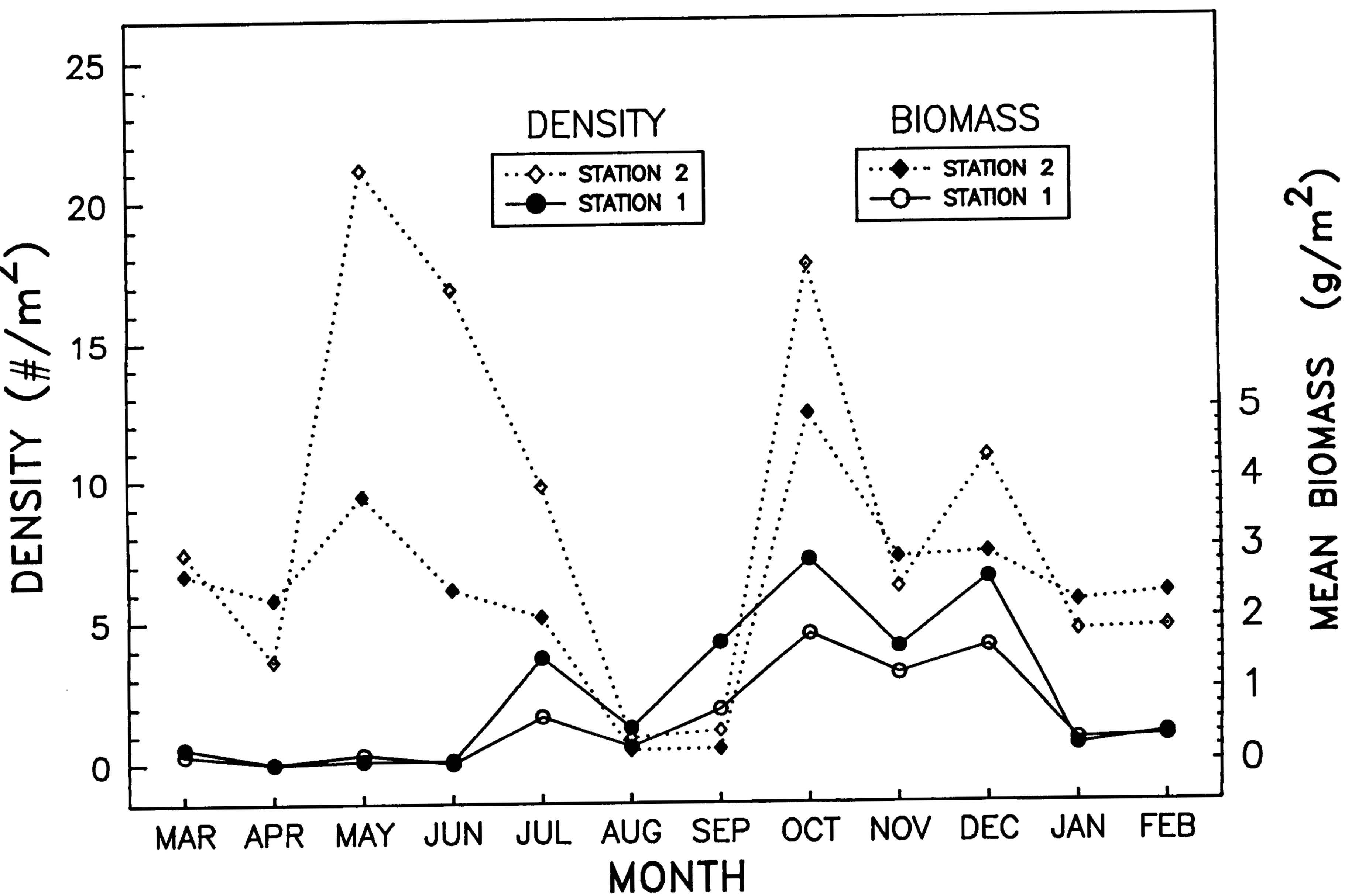
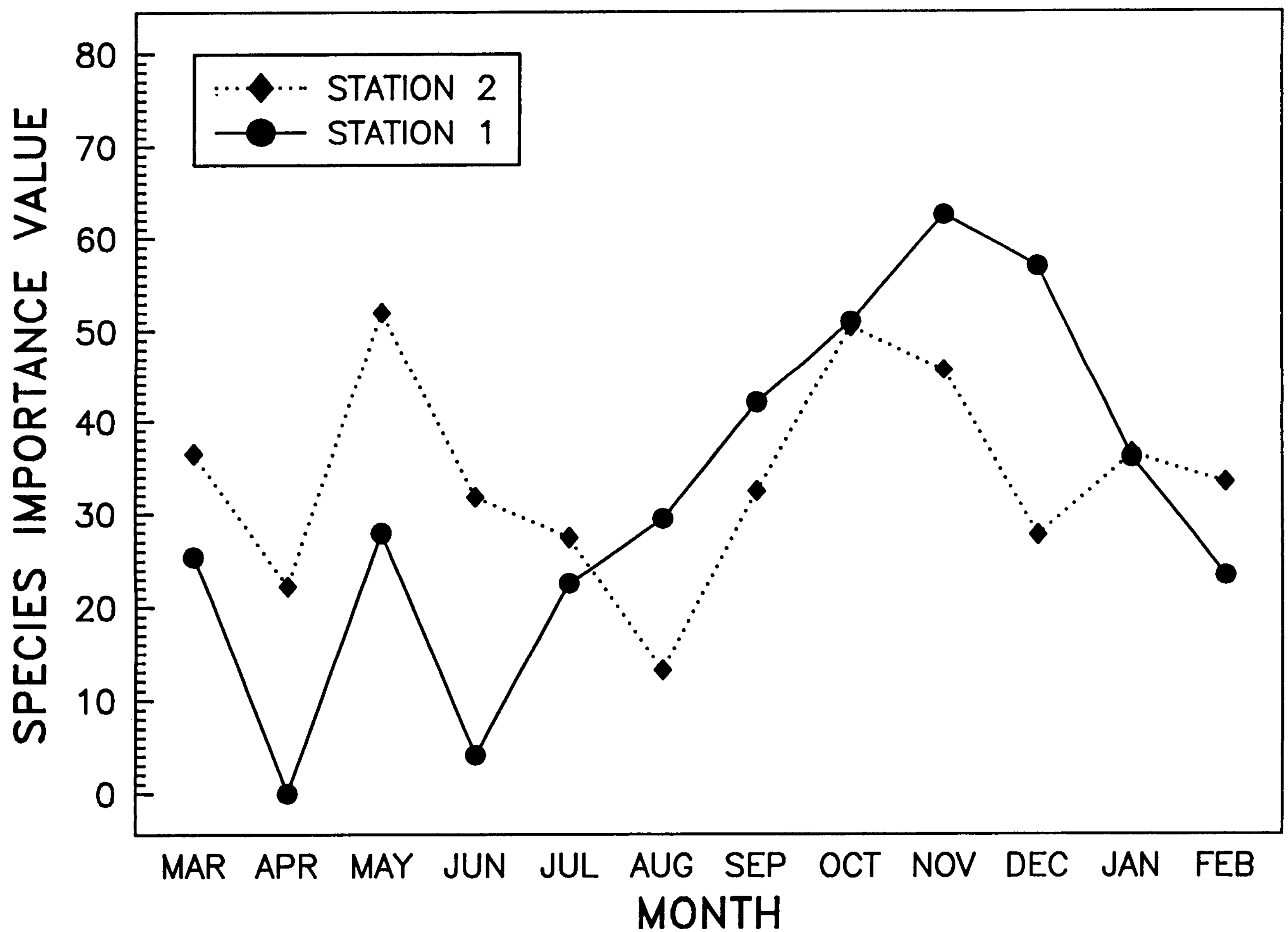
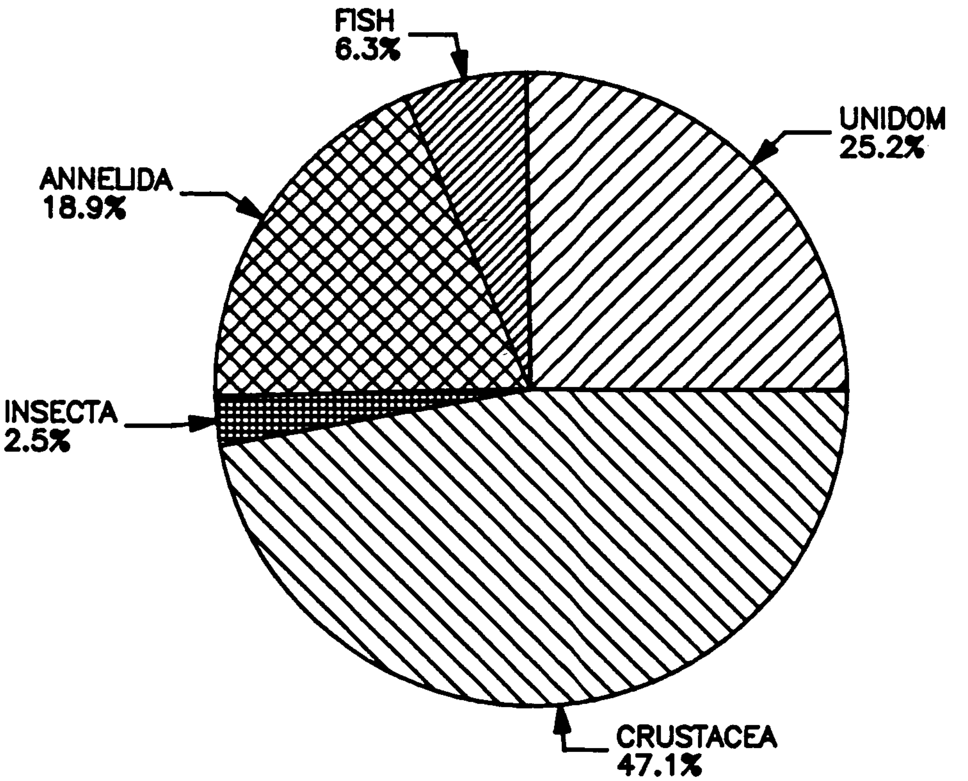

DENSITY (#/m^2)
25
20
15
10
5
0
DENSITY
STATION 2
STATION 1
BIOMASS
STATION 2
STATION 1
MEAN BIOMASS (g/m^2)
5
4
3
2
1
0
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MONTH

Figure 4. Monthly species importance values (IV) for *Microgobius gulosus* for stations 1 and 2.

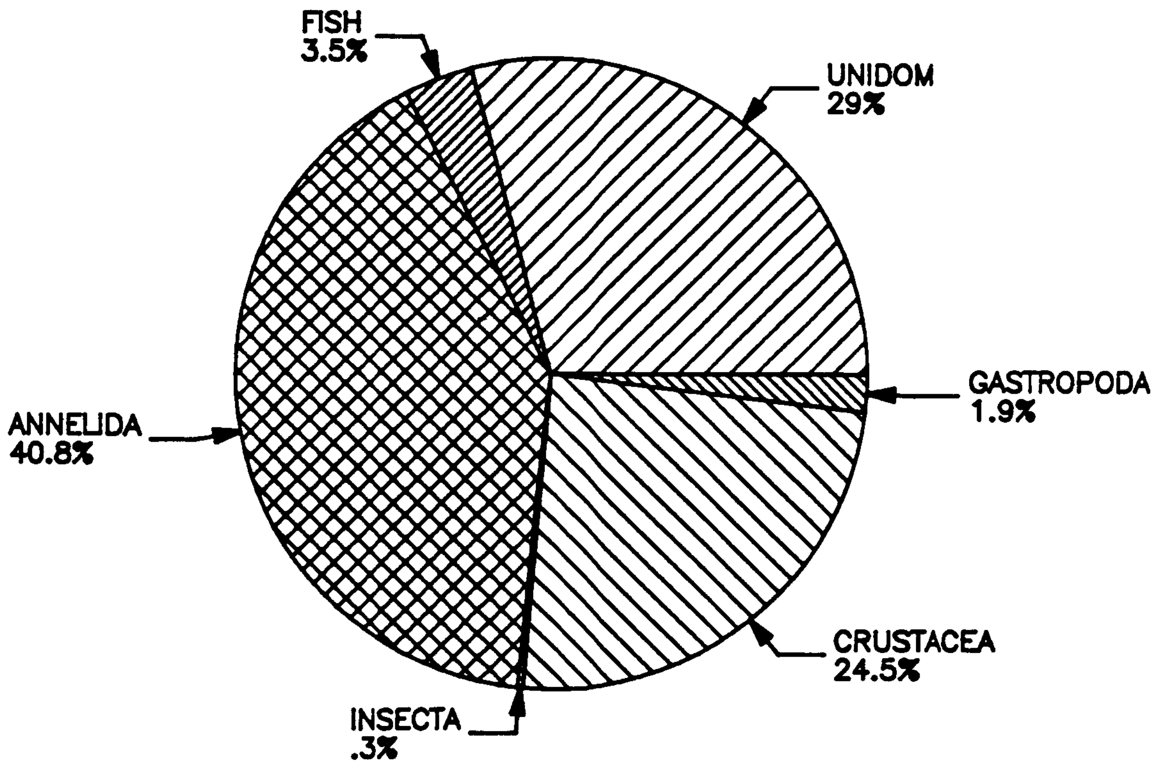


SPECIES IMPORTANCE VALUE
80
70
60
50
40
30
20
10
0
STATION 2
STATION 1
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MONTH

Figure 5. Percent composition of prey categories in stomachs and guts of *Microgobius gulosus* for station 1 (N=234) and station 2 (N=363).

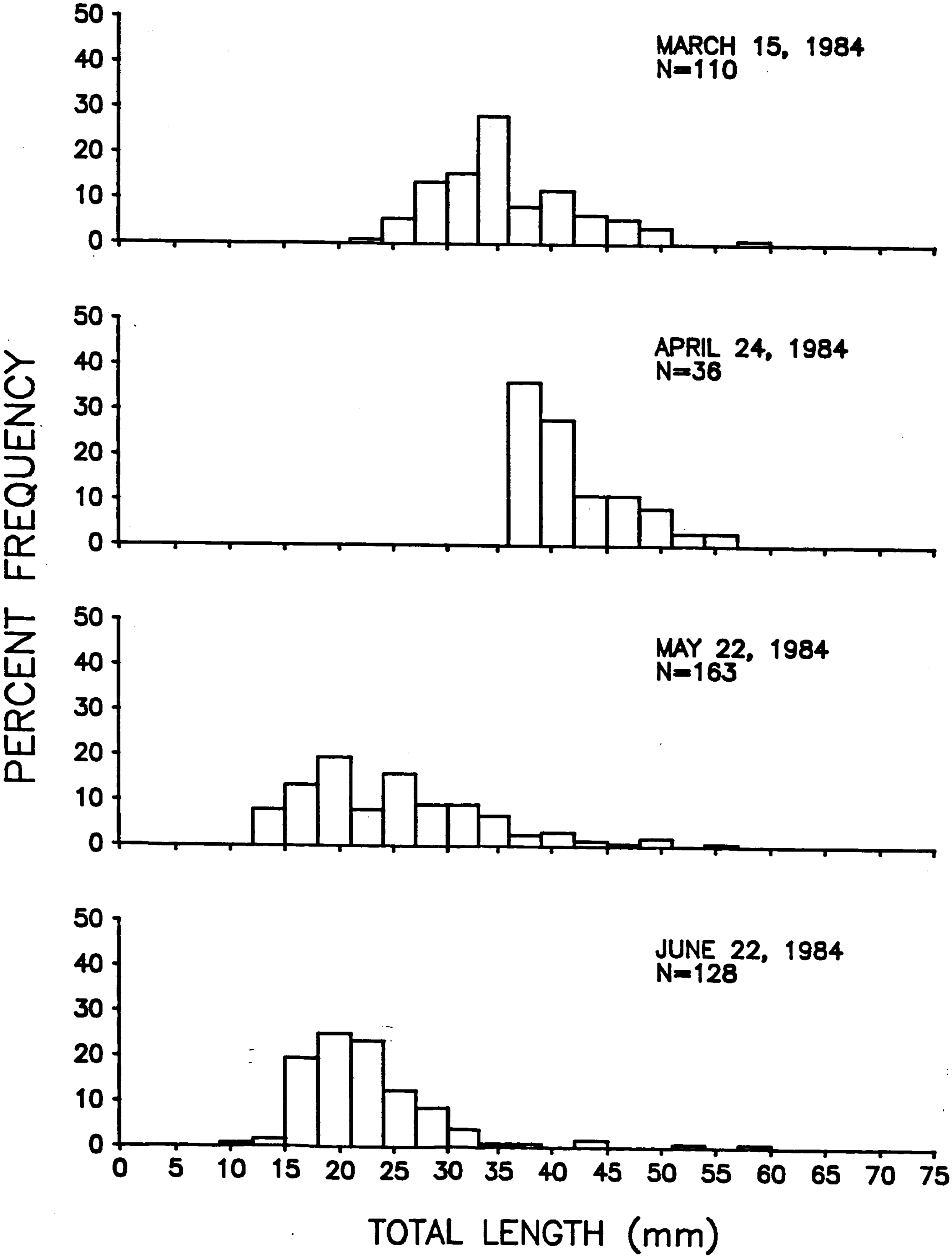


STATION 1

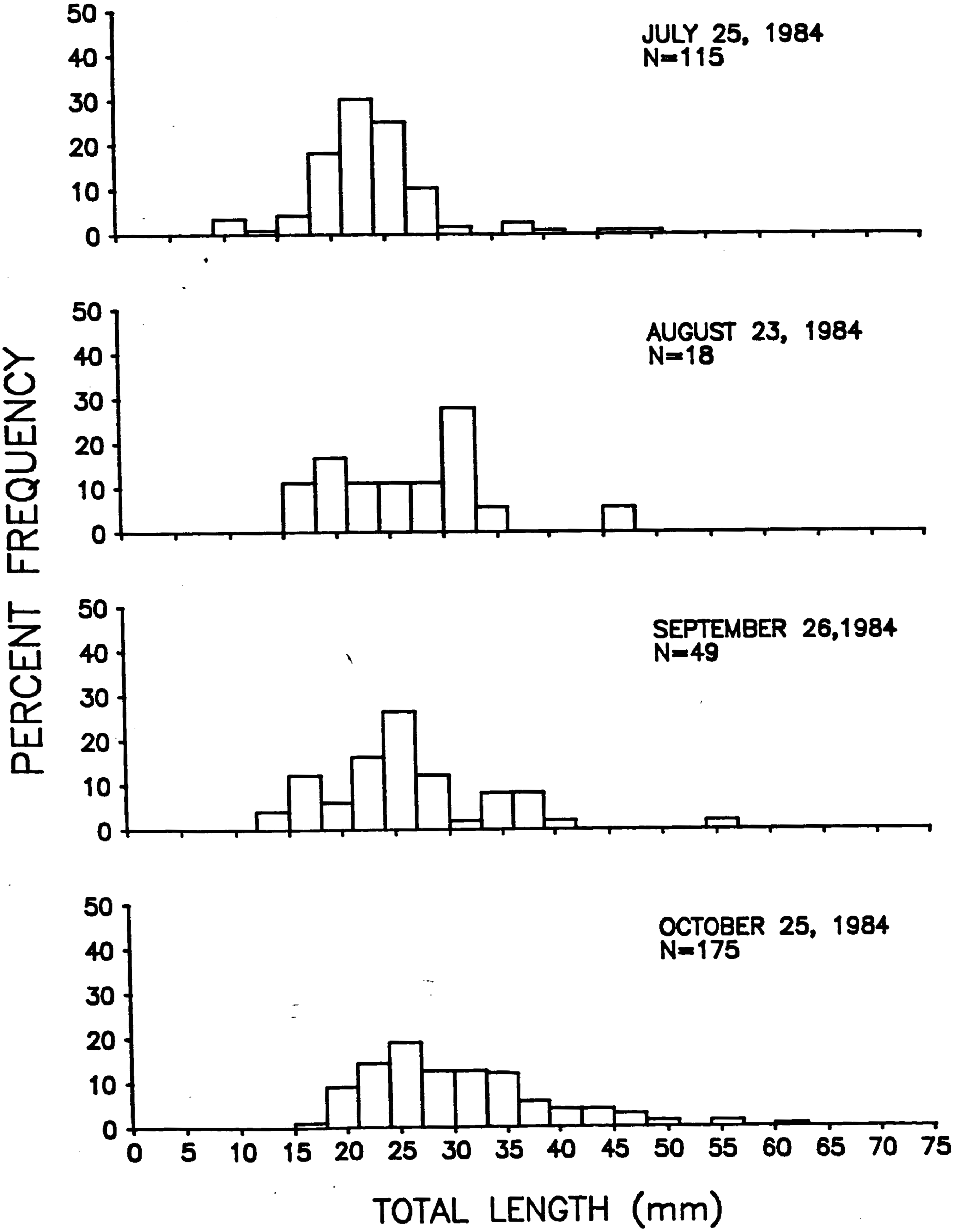


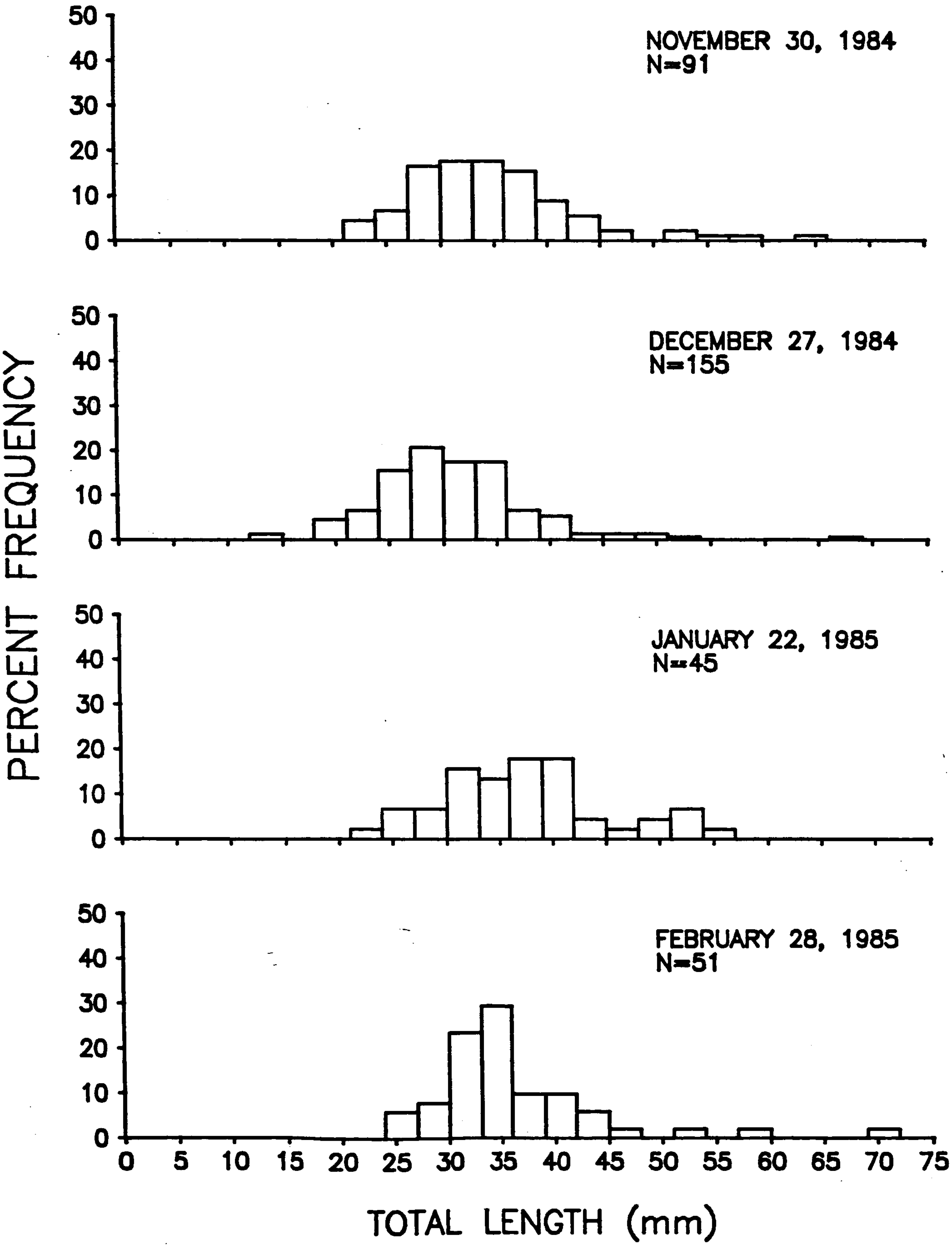
STATION 2

Figure 6 (a-c). Length-frequency histograms for Microgobius gulosus for stations 1 and 2 combined from March 1984 to February 1985.



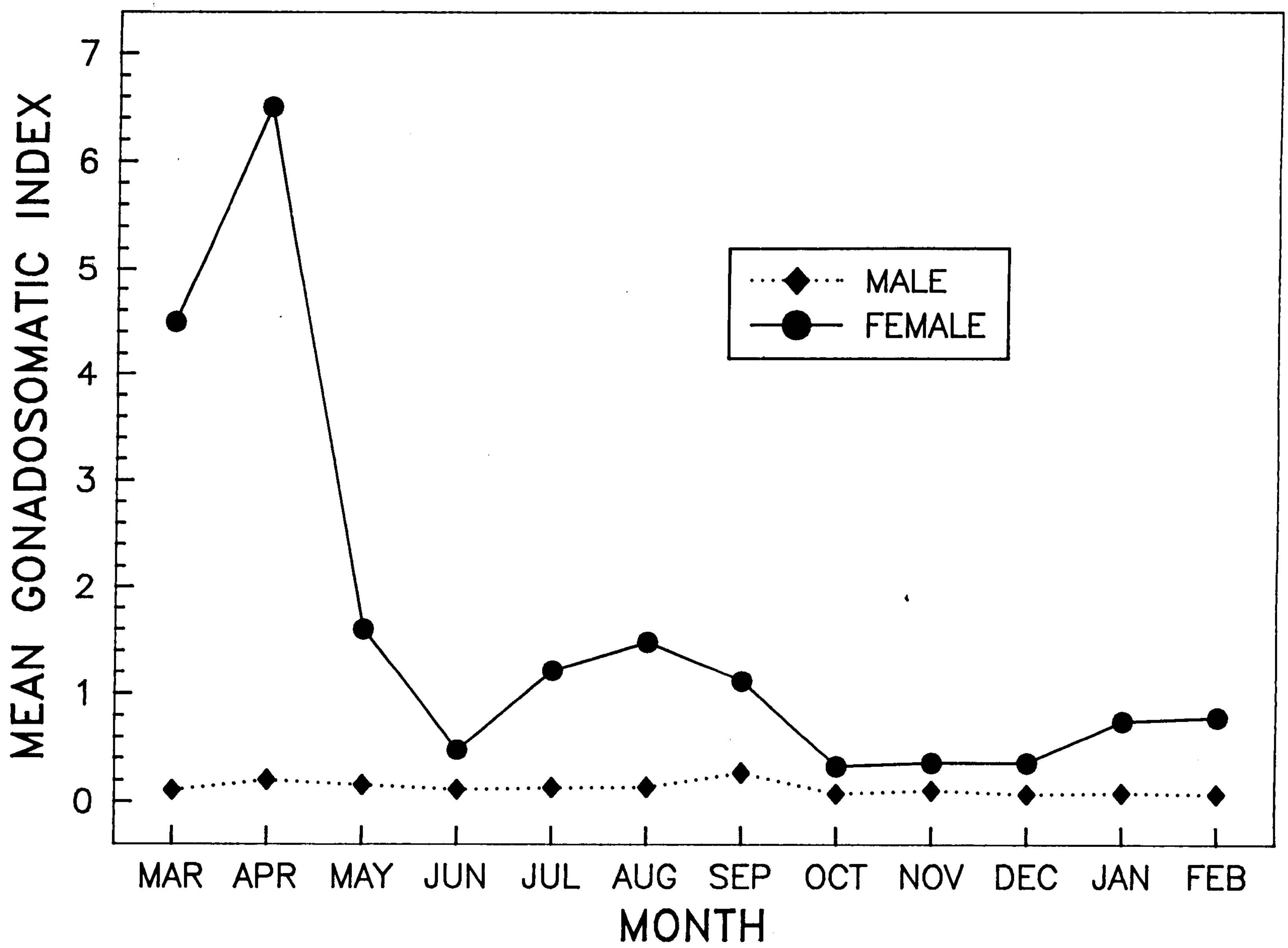
MARCH 15, 1984
N=110
APRIL 24, 1984
N=36
MAY 22, 1984
N=163
JUNE 22, 1984
N=128
PERCENT FREQUENCY
0
10
20
30
40
50
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
TOTAL LENGTH (mm)


JULY 25, 1984
N=115
AUGUST 23, 1984
N=18
SEPTEMBER 26,1984
N=49
OCTOBER 25, 1984
N=175
PERCENT FREQUENCY
TOTAL LENGTH (mm)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75
0 10 20 30 40 50



NOVEMBER 30, 1984
N=91
DECEMBER 27, 1984
N=155
JANUARY 22, 1985
N=45
FEBRUARY 28, 1985
N=51
PERCENT FREQUENCY
0
10
20
30
40
50
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
TOTAL LENGTH (mm)

Figure 7. Mean gonadosomatic indicies plotted monthly from March 1984 to February 1985.


MALE
FEMALE
MEAN GONADOSOMATIC INDEX
0
1
2
3
4
5
6
7
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MONTH